CHALLENGES OF SPACE MISSION INTEROPERABILITY

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EXECUTIVE MEETING ON
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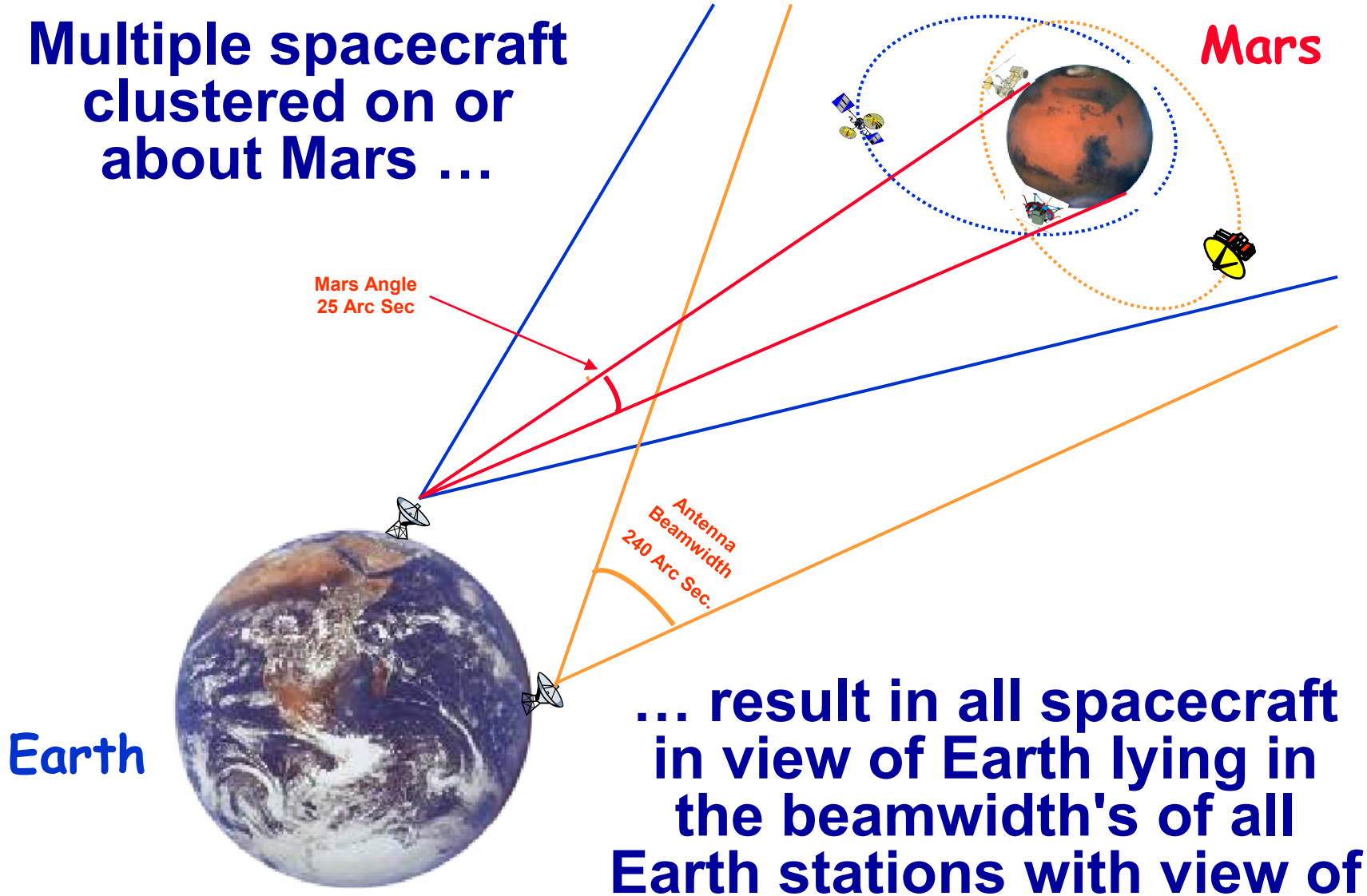
The Spectrum Problem

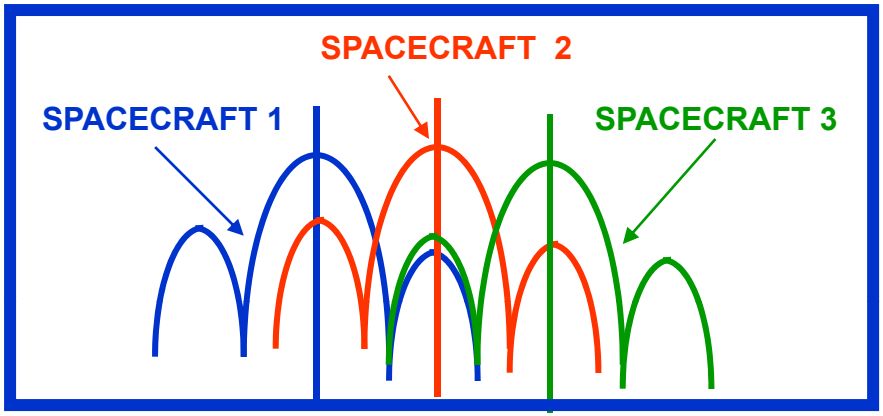
Multiple spacecraft clustered on or about Mars …

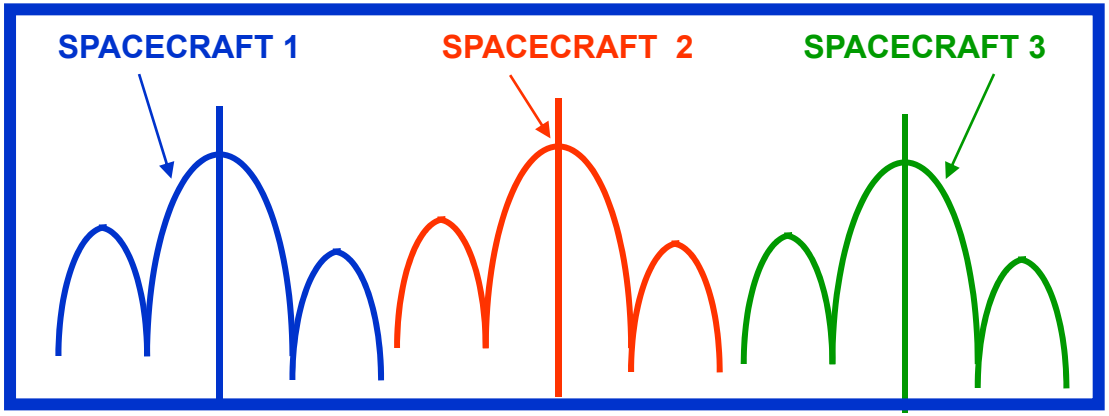


… result in all spacecraft in view of Earth lying in the beamwidth's of all Earth stations with view of Mars

Interference

If non-orthogonal telemetry spectra overlap, mutual interference is likely





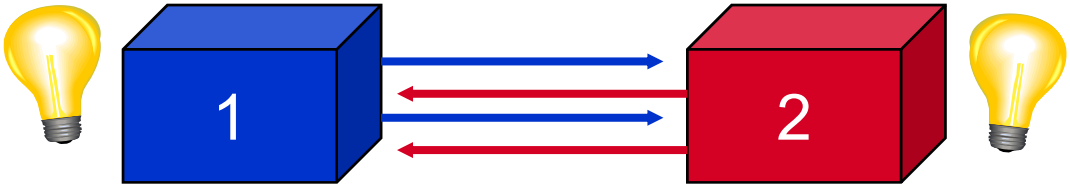
So, these spectra must be sufficiently separated

The First Step In Interoperability

International coordination of spacecraft frequency assignments for Moon & Mars missions

To achieve this, the Space Frequency Coordination Group (SFCG) has formed a Lunar-Martian Spectrum Coordination subgroup. All Agencies are strongly encouraged to support this group in order to provide the necessary the foundation for Communications Interoperability

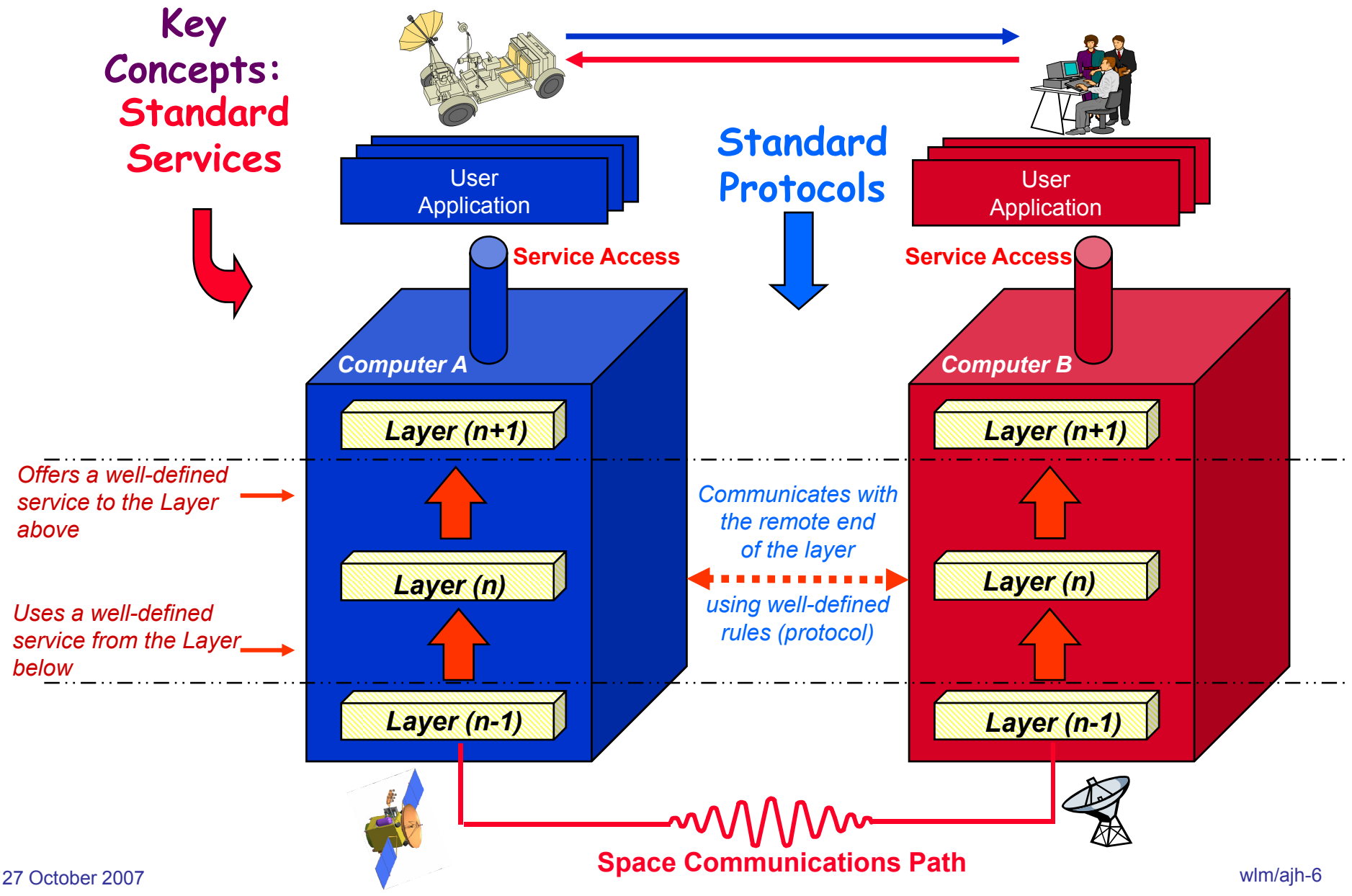
What is “Interoperability”?



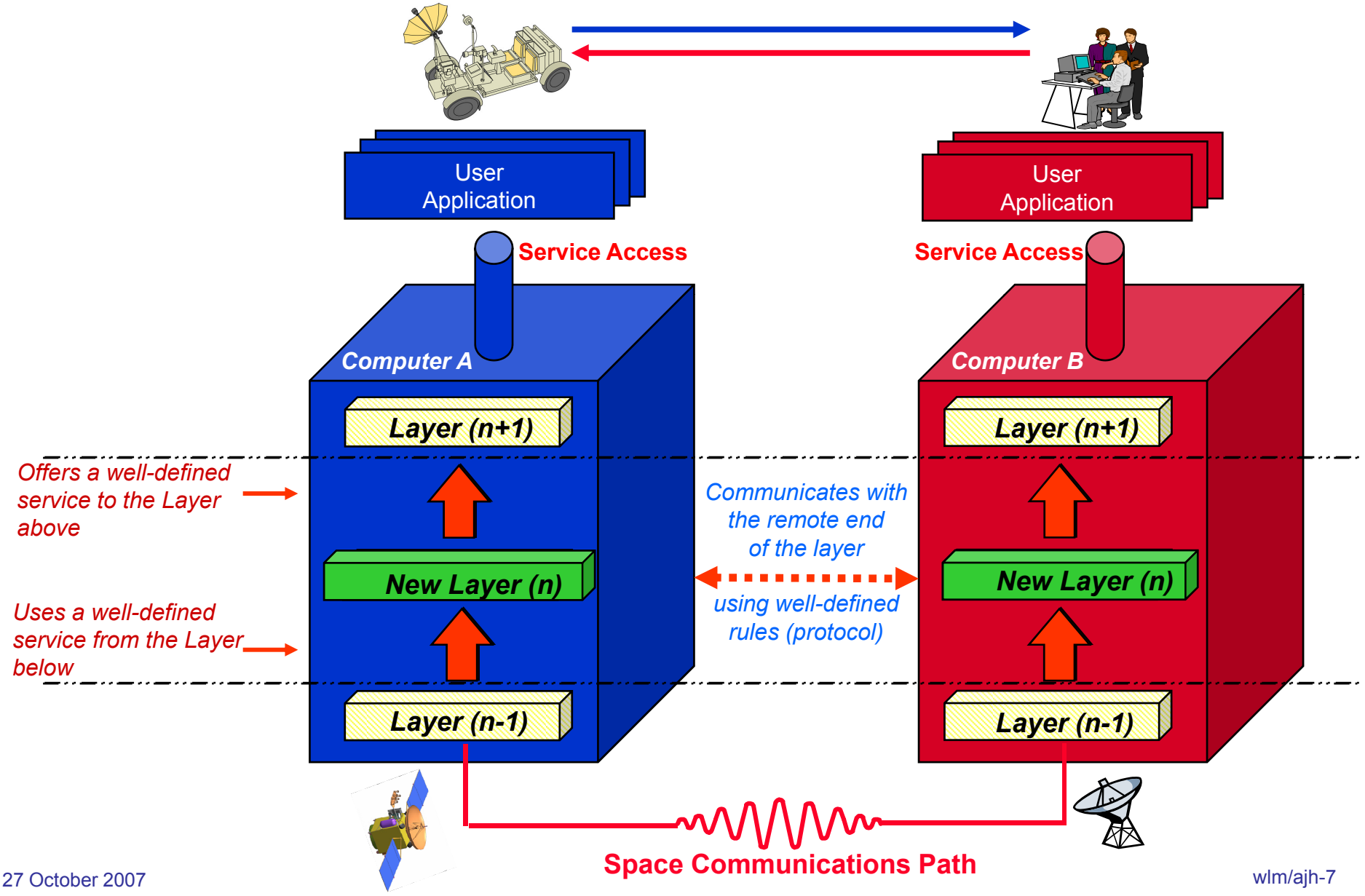
The technical capability of two or more systems or components to exchange information and to use the information that has been exchanged

[IEEE 90] Institute of Electrical and Electronics Engineers.
IEEE Standard Computer Dictionary:
A Compilation of IEEE Standard Computer Glossaries. New York, NY: 1990.

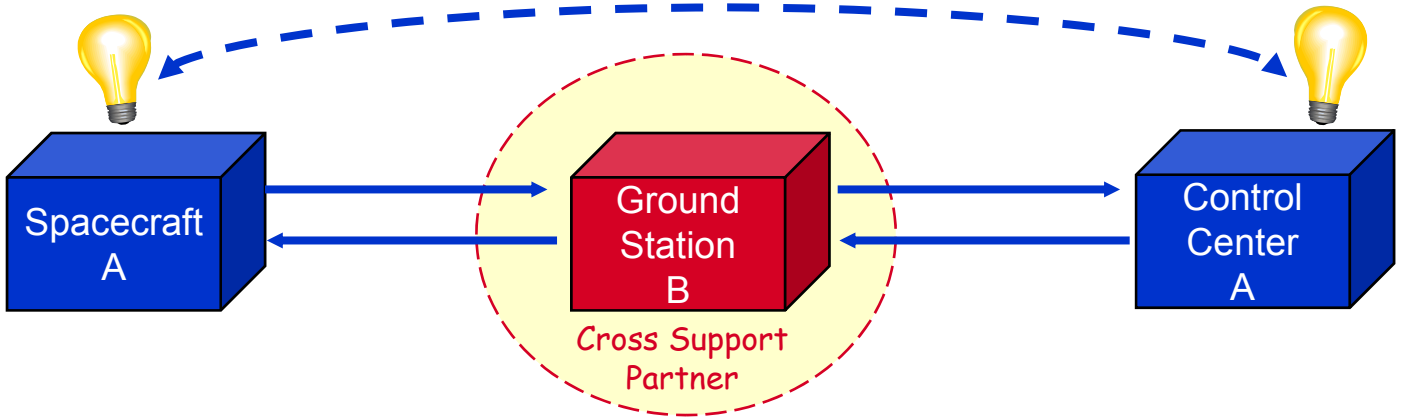
The Key to Interoperability: Standardization of Space Communications Services and Protocols



Layering Permits Interoperability to Evolve: Smooth Introduction of New Technologies

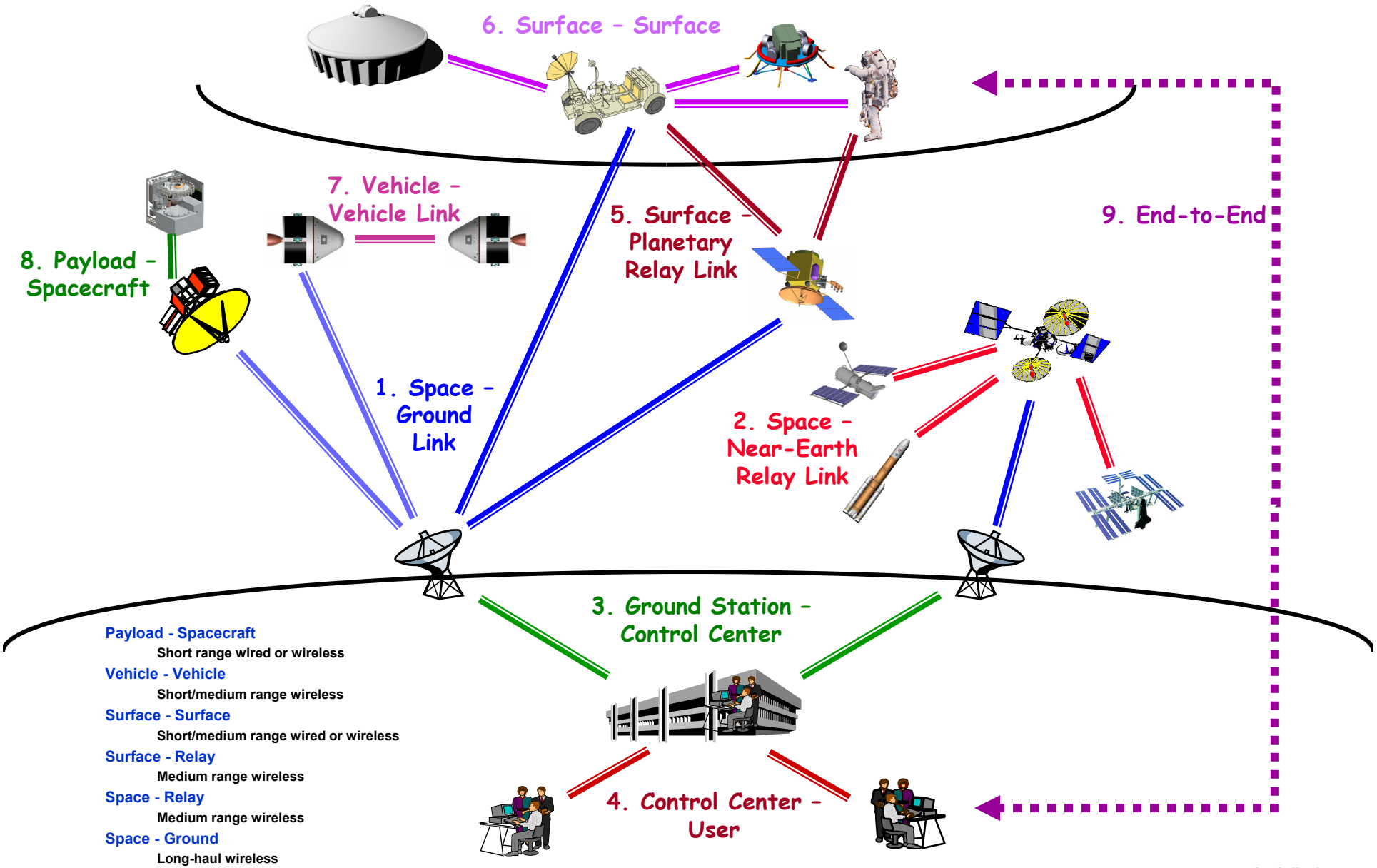


What is "Cross Support"?



An agreement between two or more organizations to exploit the technical capability of interoperability for mutual advantage, such as one organization offering support services to another in order to enhance or enable some aspect of a space mission

Potential Space Communications and Navigation Cross Support Interfaces



Payload - Spacecraft
Short range wired or wireless

Vehicle - Vehicle
Short/medium range wireless

Surface - Surface
Short/medium range wired or wireless

Surface - Relay
Medium range wireless

Space - Relay
Medium range wireless

Space - Ground
Long-haul wireless

Stages of Cross Support

1. Harmony

- Space organizations conduct independent, interference-free operations

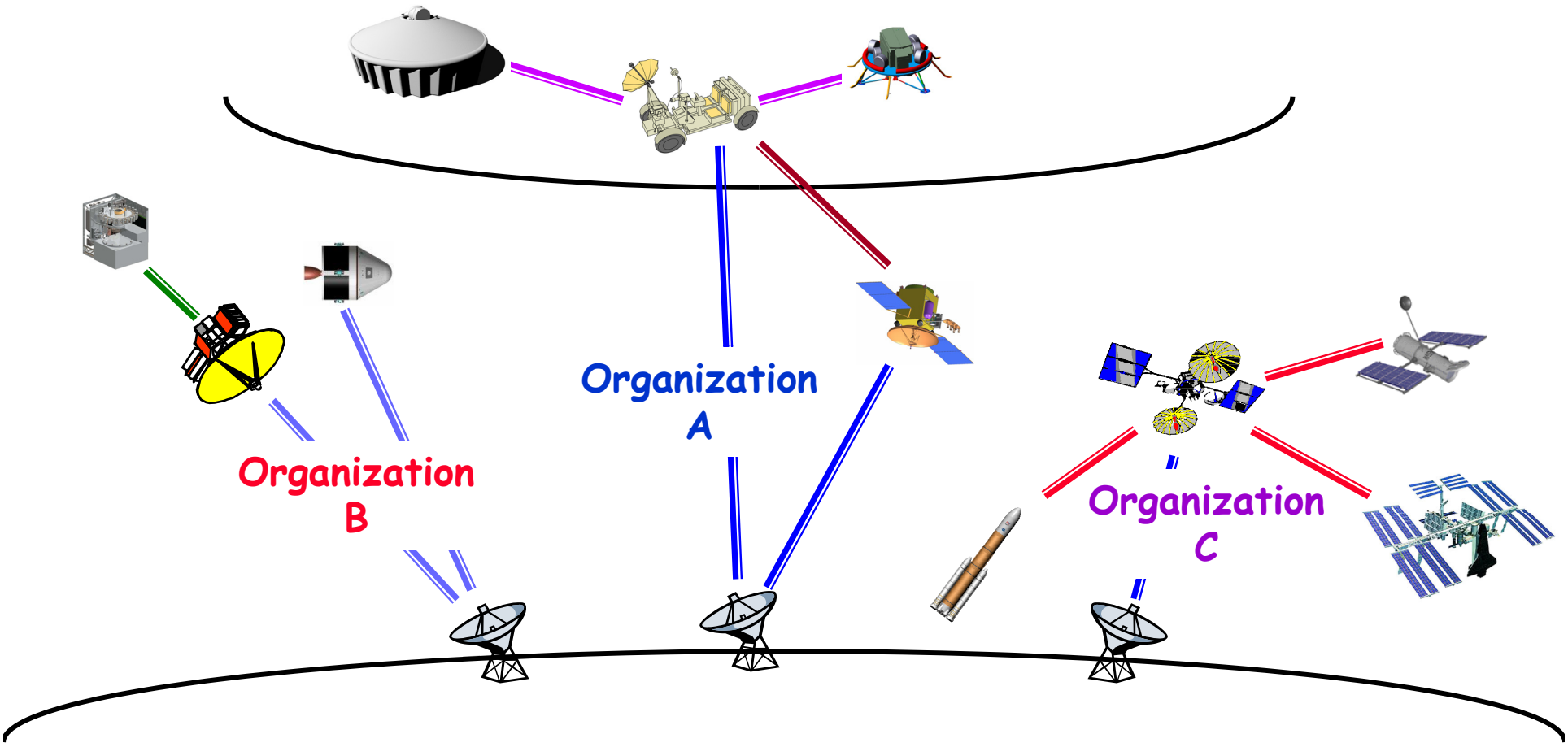
2. Cooperative Cross Support

- One organization helps another to execute its mission

3. Confederated Cross Support

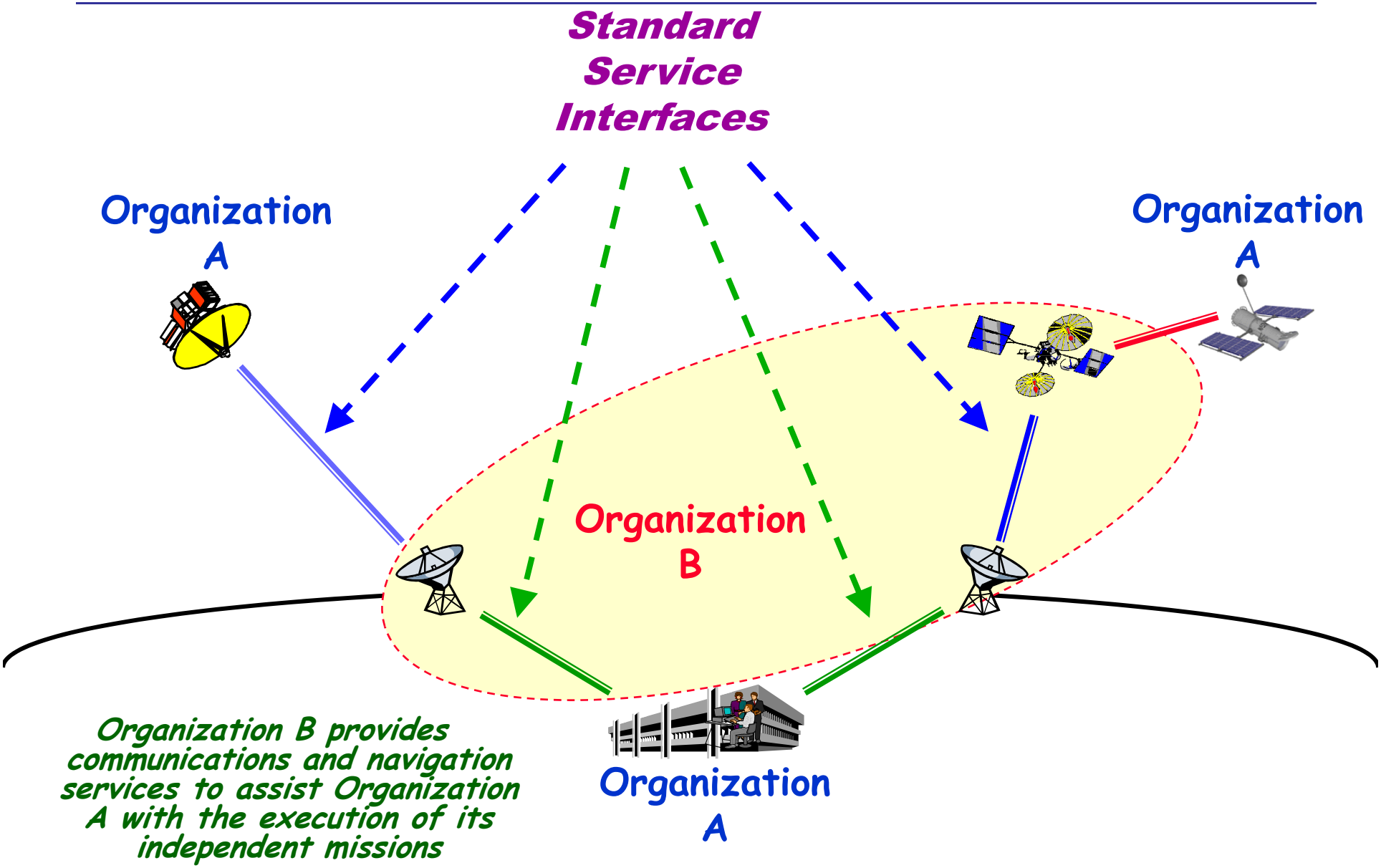
- Multiple organizations contribute independent pieces to a mission
  - 3A: preplanned
  - 3B: ad-hoc “Plug-and-Play”

Stage 1: Harmony

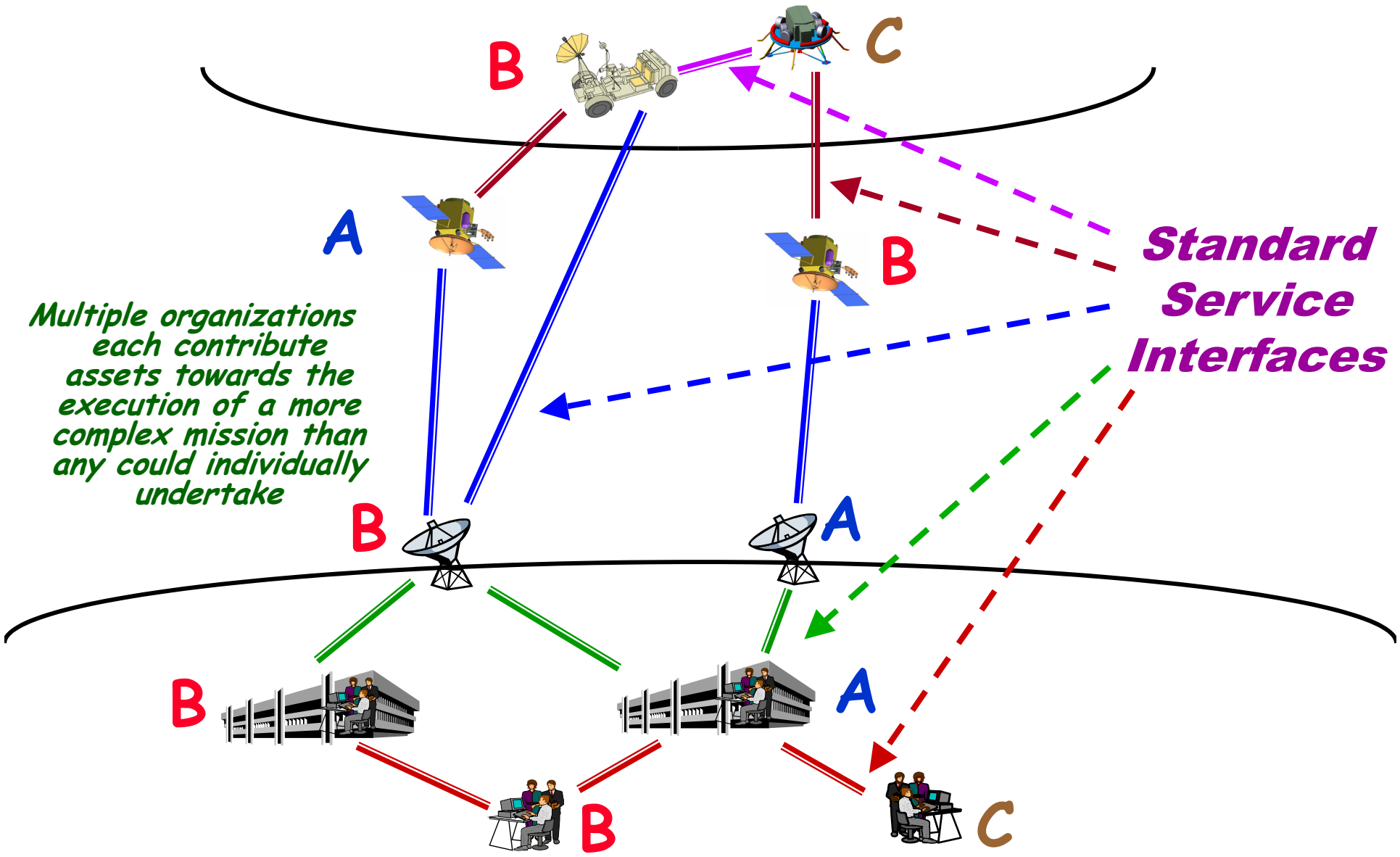


Organizations operate independently and without interference, as a result of coordinated spectrum allocations and utilization

Stage 2: Cooperative Cross Support

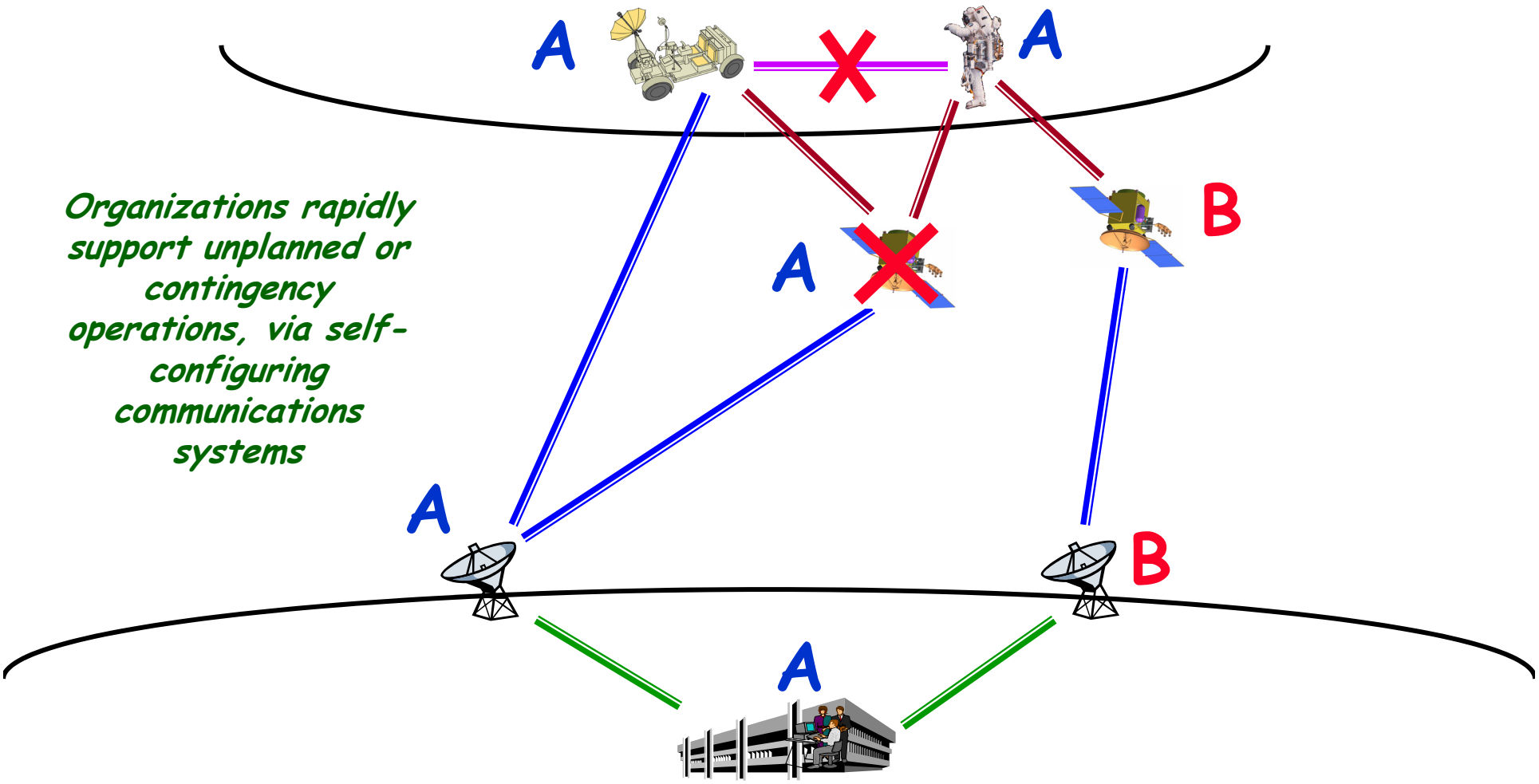


Stage 3A: Confederated Cross Support, Preplanned

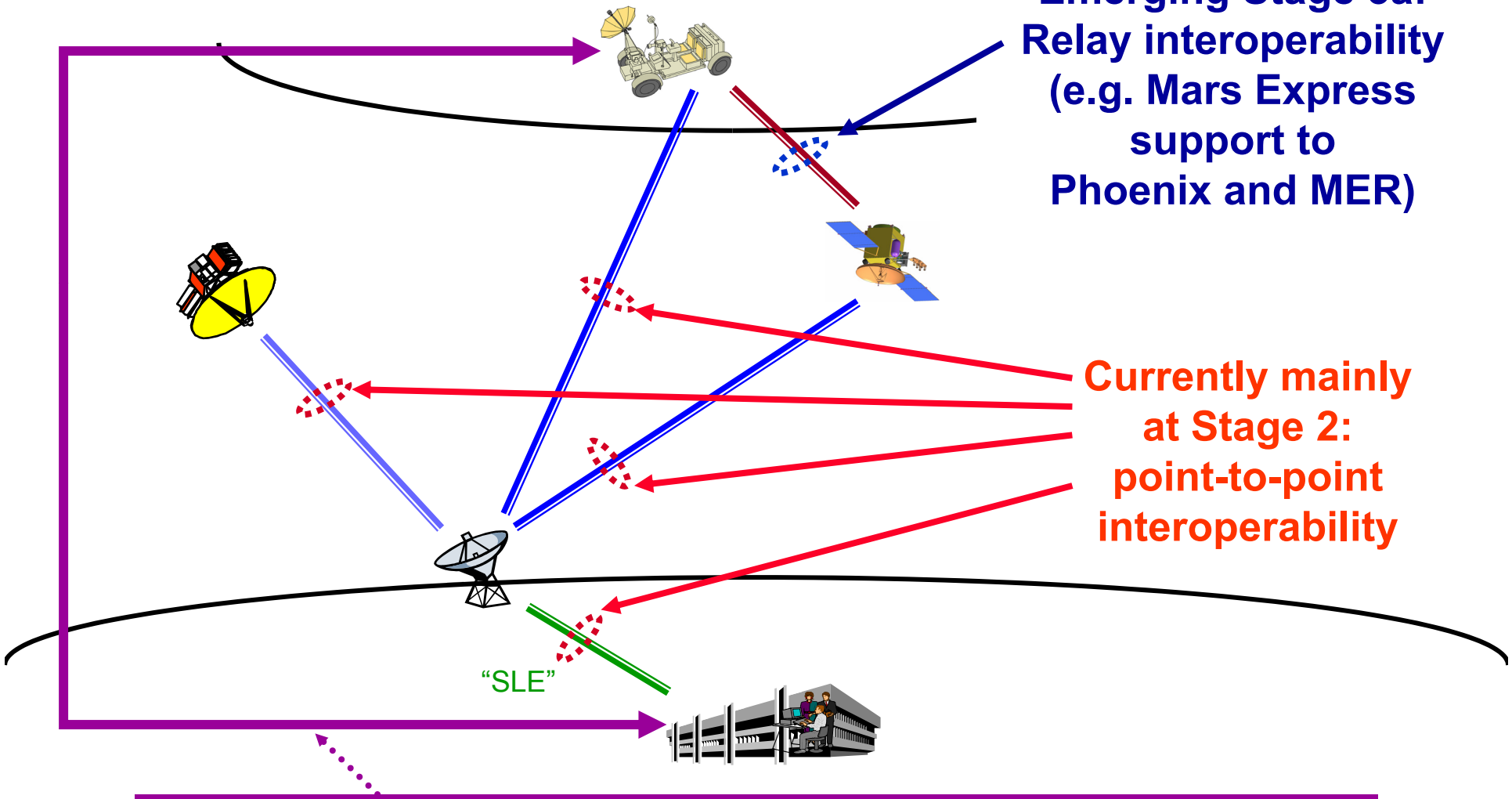


Stage 3B: Confederated Cross Support, Plug-and-Play

Organizations rapidly support unplanned or contingency operations, via self-configuring communications systems



Current State of International Cross Support



Next step: end-to-end (Internetworking) interoperability

International Coordinating Bodies for Interoperability and Cross Support

Inter Operability Plenary (IOP)

- Convened in Paris, June 1999
- Attended by ESA, France, Germany, Italy, Japan, USA
- Reached international agreement on the need for space mission interoperability, and terms of reference for the IOAG

Interagency Operations Advisory Group (IOAG)

- Convened by the Interoperability Plenary in February 2000.
- Members are ESA, France, Germany, India, Italy, Japan, USA
- High level management coordination forum; meets ~once/year

Consultative Committee for Space Data Systems (CCSDS)

- Chartered in Toulouse, October 1982
- Members are Brazil, Canada, ESA, France, Germany, Italy, Japan, Russia, UK, USA
- International space data standards authority; meets ~twice/year, 150+ attendees

Space Frequency Coordination Group (SFCG)

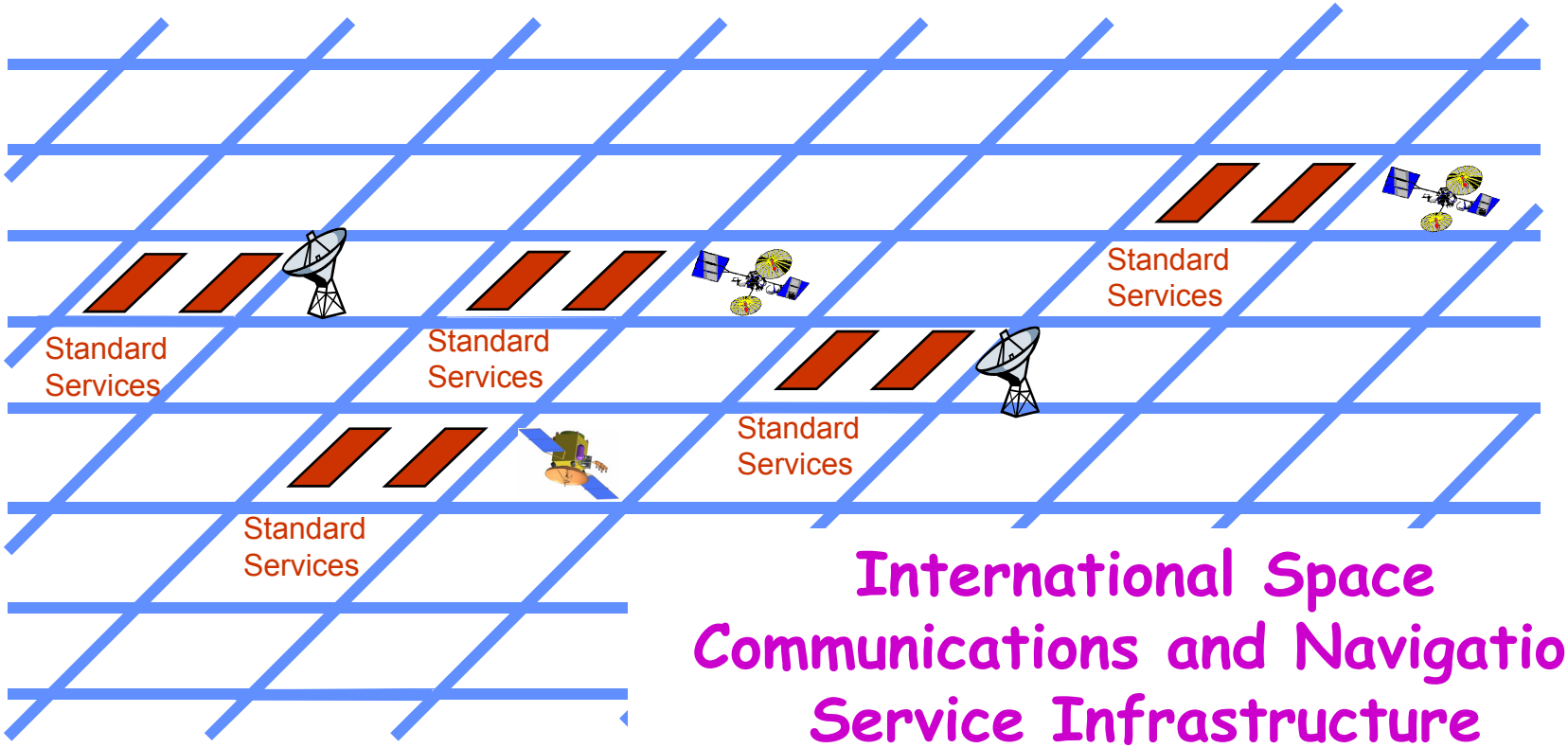
- Chartered in 1980
- Members are Argentina, Australia, Austria, Brazil, Canada, China, ESA, EUMETSAT, France, Germany, India, Italy, Japan, Korea, Malaysia, Netherlands, Russia, Spain, Sweden, Taiwan, UK, Ukraine, USA
- International spectrum utilization authority; meets ~once/year

IOAG's Definition of Interoperability

- **The mechanisms by which two or more heterogeneous systems can directly interact and exchange information without any customization or human pre-configuration of the interface between them.**

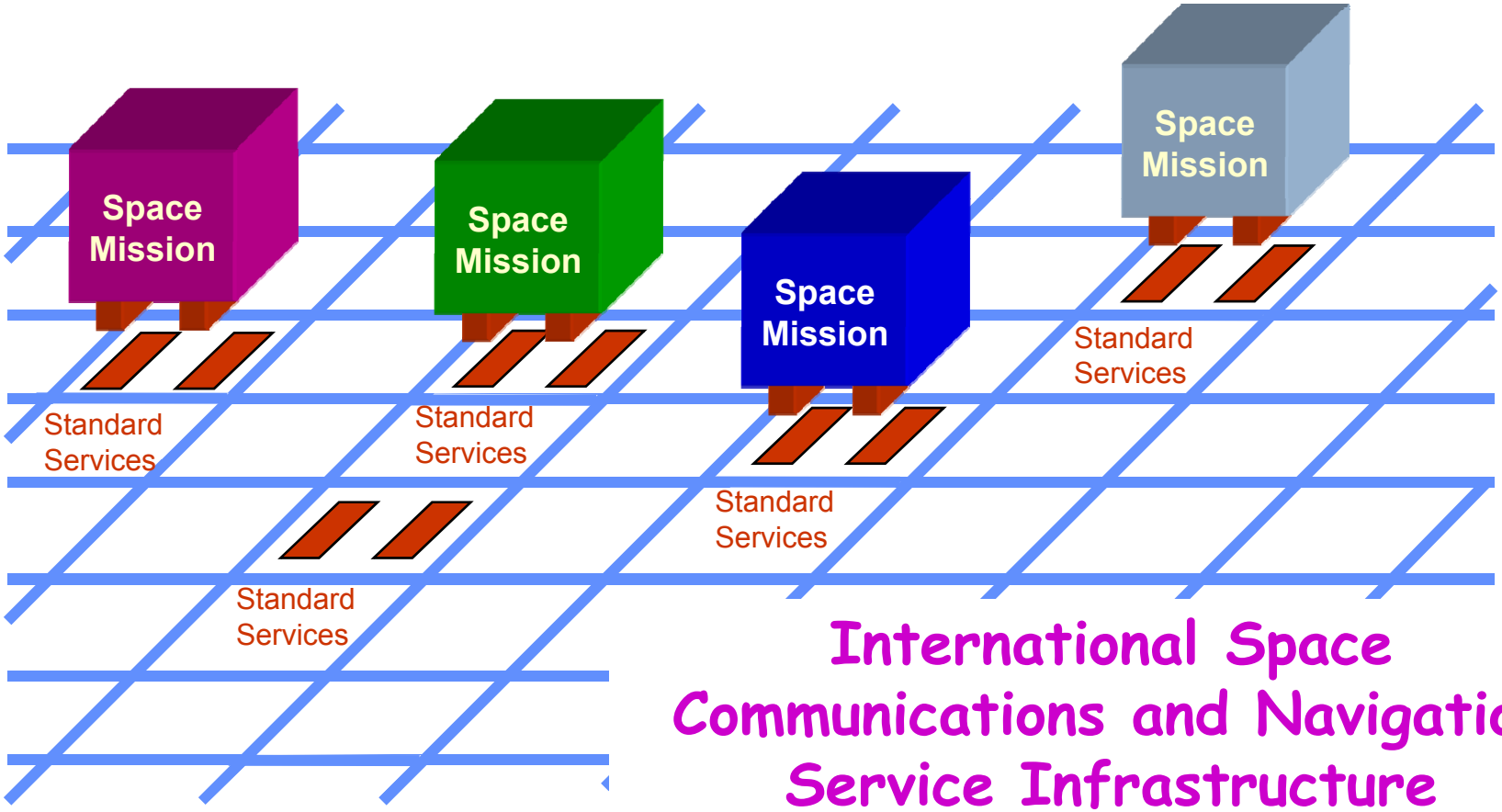
- ***It is a goal to achieve plug-and-play operations where all that is required is for each of the systems to use an agreed communications medium, after which the systems configure each other for the purpose of exchanging information and subsequently effect such exchange automatically.***

The Goal: International Level 3B Plug-and-Play



Source: Mario Merri/Mike Kearney

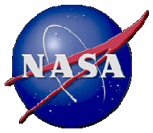
The Goal: International Level 3B Plug-and-Play



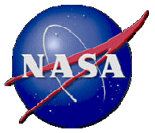
Source: Mario Merri/Mike Kearney

Summary

- **Progress towards international interoperability during the past 20+ years has been good**
  - **A mature international coordinating and development infrastructure (IOAG, CCSDS, SFCG) exists**
- **The need for future interoperability is accelerating**
  - **Many countries are now interested in exploring the same places**
- **It is an opportune time to consider convening the second Interoperability Plenary, with expanded membership, to chart the course for the next 20 years**
  - **If we don't, everyone may waste resources by re-inventing communication and navigation systems that should be standardized and routine**



Discussion?



Supplementary material

CCSDS Standardization Areas